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Fuelling Calorie Intake Decline: Household Level Evidence from Rural India*

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Abstract

In India, average per capita calorie intake has declined even as real per capita monthly expenditure has increased. Since cross sectional evidence suggests a robust positive relationship between the two variables, the trend emerges as a major puzzle. Using household-level data from 4 recent rounds of National Sample Survey data (1987–88, 1993–94, 2004–05, and 2009–10) on consumption expenditure and a novel instrumental variable estimation strategy we find strong evidence for a food-budget squeeze as an explanation of the puzzle: rising expenditures on cooking fuel have led to falling calorie intake.

JEL Classification: O1; I32.
Keywords: calorie consumption puzzle, India, instrumental variable method.

1 Introduction

One of the most enduring puzzles related to economic development in India over the past few decades is what Chandrasekhar and Ghosh (2003) have called the calorie consumption puzzle. Average calorie intake has declined over time in India even as real consumption expenditures (and by most measures real per capita incomes) have increased. Since cross sectional evidence shows a robust positive relationship between per capita income and calorie intake, the time series

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pattern in India clearly presents a puzzle. Moreover, the puzzle has been around for a long time. Data collected from large-scale, nationally representative consumption expenditure surveys (CES) conducted roughly every five years by the National Sample Survey Organization (NSSO), show that this trend starts in 1972–73 (NSSO, 1996).[1]

Deaton and Dreze (2009) provide a comprehensive analysis of the facts pertaining to, and possible interpretations of, this puzzle with data running from 1983 to 2004–05. They find that estimated average calorie intake in rural areas declined by about 10 percent over the two decade period between 1983 and 2004–05, the decline being higher at the upper end of the expenditure distribution. Urban areas witnessed a milder decline in estimated average calorie intake. Real average monthly per capita expenditure (MPCE) increased substantially (about 22 percent in rural areas in India) over the same period. When we extend the analysis to 2009–10, we find a continuation of the same trend (see Table 1). Over the two decade period from 1987–88 to 2009–10, average calorie intake in rural India declined by 14%, from 2291 Kcal per capita per day to 1971 Kcal per capita per day. Over the same period, average inflation-adjusted per capita expenditure increased by 28%.

Alternative explanations that have been offered to explain the calorie consumption puzzle include declining calorie needs (Rao, 2000; Deaton and Dreze, 2009; Eli and Li, 2013), changes in the relative price of food (Gaiha et al., 2009, 2010; Patnaik, 2010a), dietary diversification (Rao, 2000; Mittal, 2007; Landy, 2009), voluntary choice of luxuries like TVs over food (Banerjee and Duflo, 2011), under-reporting of calorie intake due to eating outside home (Smith, 2013), and a food budget squeeze (Mehta and Venkatraman, 2000; Sen, 2005; Basu and Basole, 2012).[2] In this paper we provide household-level evidence for a food-budget squeeze. Using an instrumental variable em-

[1]The NSSO conducts nationally representative large-scale consumer expenditure surveys roughly every 5 years, which are referred to as the "thick rounds". In between the thick rounds, the NSSO conducts annual smaller scale surveys, whose quality and scope is much more limited. For the analysis in this paper, we use data from "thick rounds" only.

[2]Another explanation has been to attribute falling calorie intake to absolute declines in total expenditures (and incomes), especially at the lower ends of the expenditure distribution in rural India. There has been a vigorous debate in the pages of the Indian journal *Economic and Political Weekly* over whether real expenditures have been rising or falling (Patnaik, 2004, 2007, 2010a,b; Deaton and Dreze, 2009, 2010). Using our own food price index constructed from unit-level NSS data from the "thick" rounds of the consumption expenditure survey (CES) since 1987–88, and also a state-level consumer price index for agricultural labourers (CPIAL), we find that total household expenditures in rural India have risen in real terms over this period. Hence we do not pursue the line of explanation that relies on the claim of falling real expenditures.

pirical strategy we show that rising expenditures on cooking fuel cause a decline in calorie intake. Expectedly, the relative price of food as well as diversification of diets also emerge as important factors from our analysis.

Before we outline the empirical strategy and contribution of this paper, it might be worthwhile thinking about why we care about declining calorie intake in the first place. First, Deaton and Dreze (2009) show that even though anthropometric measures, such as height-for-age, weight-for-height, and weight-for-age among children, and adult body mass index (BMI) have improved in India, they are still among the worst in the world. And improvements are slow relative to what might be expected given recent rates of economic growth. Second, it is a striking and potentially worrisome fact that for the vast majority of rural Indians per capita calorie intake is still below both the 1972 poverty line norm of 2400 Kcal per capita per day for rural areas and the more recent standards developed by the Indian Council for Medical Research[3]. The question remains, would people voluntarily reduce calorie intake while falling well short of basic nutritional requirements? Third, an implication of increasing average real expenditure and declining average calorie intake is the divergence between expenditure-based measures of poverty and calorie-based measures of under-nutrition. Even as the head count ratio has declined over time, prevalence of under-nutrition has increased, a paradoxical phenomenon that has been studied previously (Mehta and Venkatraman, 2000; Patnaik, 2007; Ray, 2007; Smith, 2013). Taken together, the continued poor performance of India in improving child and adult nutrition and the relatively low levels of calorie intake in a significant proportion of the population suggest that purely voluntary explanations such as reduced intake due to reduced needs or diversification of the diet may not suffice. Factors outside the control of households may also be at work.

In this paper, we offer evidence for one such mechanism: a squeeze on the food budget (Mehta and Venkatraman, 2000; Sen, 2005; Deaton and Dreze, 2009). Although expenditures on food as well as non-food items are a result of household-level decision-making processes, these decisions

[3]Over the years, the Indian Council for Medical Research (ICMR) has recomputed the Indian calorie norms informed by improved methodologies and using more complete information. The most recent figures for Indian calorie norms were released by the ICMR in 2009. For men, the calorie norms (measured in Kcal per day) were as follows: 2320 (sedentary work), 2730 (moderate work), 3490 (heavy work). The corresponding norms for women were: 1900 (sedentary work), 2230 (moderate work), 2850 (heavy work) (ICMR, 2009, Table 4.14).

occur in the larger context of structural changes in the economy such as loss of access to common property resources, increasing informalization of the labour market, decline in livelihood options in rural areas, and changes in the supply of social services by the State, all of which can affect expenditures on healthcare, education, fuel, transportation, and other services. A food-budget squeeze can arise if rapidly rising expenses on such non-food essentials absorb all the increases in total expenditures and keep real expenditures on food from rising.

Basu and Basole (2012) had used a state-level pseudo-panel dataset to investigate the calorie consumption puzzle, and had found evidence in support of the food budget squeeze hypothesis even after controlling for alternative factors like dietary diversification, improvements in the epidemiological environment, and changes in share of the agricultural workforce. But the empirical analysis had two shortcomings. First, by using state-level aggregation, they were not using information available at the household level. Second, the empirical model did not allow them to cleanly identify the effect of non-food expenditures on calorie intake.

In this study, we improve upon the analysis in Basu and Basole (2012) by addressing both these shortcomings. First, we use household-level consumption data for rural India from four recent "thick" rounds – 1987–1988 (43rd round), 1993–1994 (50th round), 2004–2005 (61st round), and 2009–10 (66th round) – of the CES conducted by the National Sample Survey Organization (NSSO).[4] The large sample increases the statistical power of our analysis. Second, we use a instrumental variable empirical method to deal with the potential problem of endogeneity. This allows us to advance the causal claim that increasing expenses on cooking fuel cause a decline in calorie intake.

Our empirical strategy uses household-level variation within expenditure deciles and geographical regions over time to estimate the effect of increases in real fuel expenditure on calorie intake. Since expenditure on fuel and food are likely to be jointly determined by households, our key explanatory variable of interest is endogenous. To address the problem of endogeneity, we instrument real expenditure on fuel with a dummy variable for the source of cooking energy (0 for predominantly non-commercial sources, 1 for commercial sources). Use of commercial sources of cooking

[4]We leave out 1999–2000 (55th round of the NSS) due to well-known data problems caused by mixing up of recall periods.

energy, i.e., coke & coal, LPG, kerosene and electricity, as opposed to the use of predominantly non-market sources like firewood (fuelwood) & chips, gobar gas, and dung cake entails significantly higher expenditures on cooking fuel.[5]

The switch from fuelwood or dung to LPG or kerosene (movement up the "energy ladder") is positively correlated with income (Pachauri and Jiang, 2008).[6] But controlling for income, change in fuel usage is also a function of supply-side changes beyond the control of individual households such as improved distribution networks and availability of commercial fuels, deforestation, loss of access to common property resources, acquisition of forest land for mining, industrial and infrastructural projects, and changing opportunity costs of women's time due to increased availability of non-farm employment (Heltberg et al., 2000; Vishwanathan and Kumar, 2005; Rao and Reddy, 2007; Cooke et al., 2008; Gundimeda and Köhlin, 2008; Pachauri and Jiang, 2008; Joon et al., 2009). It is this exogenous variation that allows us to identify the causal impact of fuel expenditure on calorie intake. In other words, conditional on the included regressors in the model (income, relative prices, epidemiological environment, primary occupation, education, caste, religion and other demographic variables), the source of cooking fuel does not have a direct impact on calorie intake but affects calorie intake only through its impact on the real expenditure on fuels.

One way to understand the implication of the switch from non-commercial to commercial sources of cooking energy is to think about the cash requirements entailed by both. Whereas non-commercial sources of cooking fuel are largely obtained without cash transactions commercial sources require cash purchase.[7] Thus, the switch from non-commercial to commercial sources is tantamount to an increase in the price of cooking fuel. Since consumed calories predominantly come from cooked food, the demand for cooking fuel is relatively inelastic. Hence, the switch from non-commercial to commercial sources, which is equivalent to an increase in the price of cooking

[5]Since fuelwood collection is an energy-intensive activity, the choice of fuel can also affect calorie intake via calorie needs. We address this problem in two ways. First, we exclude all households that depend primarily on fuelwood from our analysis. Second, we exclude only those households that report acquiring fuelwood through what the NSS calls "free collection" which refers to the methods of gathering fuelwood over a large area.

[6]This is generally seen as a positive fact from developmental, environmental and health perspectives. We accept this view but would like to point out that the switch also entails a new financial burden on the household and as such may be an important variable in explaining the food budget squeeze.

[7]The only cost of fuelwood and dung, for example, is the opportunity cost of time spent in their collection and, in the case of dung, alternative uses of the fuel such as fertilizer.

fuel, entails significantly higher expenditures. This leaves lower purchasing power for food, leading (along with other factors) to lower calorie intake.[8]

In our empirical analysis, we find strong evidence in favour of such a food budget squeeze, even after controlling for income (proxied by expenditure), diet diversification, relative price changes (of food and cereals), changes in the pattern of occupation, the epidemiological environment, education, caste, religion and other demographic factors. We show that households which spend more on fuel consume lower calories: our regression results suggest that a 1 percent increase in real expenditure on fuel between 1987–88 and 2009–10 caused between 0.07% and 0.18% decline in calorie intake.

The rest of the paper is organized as follows. Section 2 presents a brief summary of the explanations that have so far been offered in the literature about the calorie consumption puzzle. Section 3 introduces the data source and presents descriptive statistics. Section 4 presents trends in the food and non-food budget over the analysis period. The empirical model and the instrument are discussed in section 5. Section 6 contains a discussion of the main results of the paper. Section 7 concludes the paper with some policy implications.

2 Alternative Explanations of Calorie Intake Decline

A large and rapidly growing literature has engaged with the calorie consumption puzzle in India. This literature has been comprehensively surveyed in Deaton and Dreze (2009) and Smith (2013), and we draw on both papers to provide a brief summary of the alternative explanations that have been offered to understand the puzzle.

An influential line of explanation sees the calorie intake decline as the result of decline in calorie needs. After an analysis of the empirical evidence related to all the major factors that have been offered, Deaton and Dreze (2009) tentatively accept declines in required calories as the most plausible explanation. They note that decline in the need for calories can arise due to changes in occupational structure (the main factor being reduction in proportion of the workforce engaged in agricultural work), mechanization of agricultural work, improvement in the epidemiological en-

[8] An earlier literature on the links between environmental degradation and women's labour had indicated towards the possibility of such a mechanism. For instance, see Cecelski (1987, pp. 51).

vironment (e.g., access to better drinking water and health care), decline in fertility, and labour saving technical change within the households (e.g., increasing use of consumer durables).

While their hypothesis is plausible, they present no direct evidence in support of it. A recent study that sets out to explain India's "missing calories" in terms of declining needs also concludes that while the rural-urban difference in calorie intake can be explained by reduced needs, declining needs are not enough to explain the downward shift in calorie Engel curves over time (Eli and Li, 2013). Further, it is well-known that calorie intake has been falling across all deciles of the expenditure distribution, with the exception of the lowest decile, where it is stagnant. It is not clear that a decline in calorie needs, even if it has occurred, can completely explain the decline in average calorie intakes, especially for the lower expenditure deciles where calorie intakes are still very low. In 2009, all MPCE deciles except the top three fell below the 1972 poverty line norm of 2400 Kcal per capita per day and even below the updated 2009 norms published by the Indian Council of Medical Research (author's calculations and ICMR (2009, Table 4.14)). The lower five MPCE deciles lie far below the norm, having average calorie consumption of less than 2100 Kcal per capita per day. The "calorie needs" explanation requires us to believe that a significant proportion of rural Indians is voluntarily foregoing food consumption even while falling far short of the basic minimum nutritional requirement.

Another line of explanation is that the decline in calorie intake has been caused by the relative increase in the price of food (Gaiha et al., 2009, 2010; Patnaik, 2010a). Although Deaton and Dreze (2009) and Balakrishnan (2010) show that the relative price of food displays no clear trend since the early 1980's despite wide fluctuations, we include this as control on our model. A third line of explanation rests on dietary diversification. A slow but steady diversification of diets, in both rural and urban India, has been noted by several scholars (Rao, 2000; Mittal, 2007; Landy, 2009). Since diversification of diets imply the substitution of cheaper with more expensive sources of calories, e.g., rice and wheat with vegetables, nuts and fruits, it might lead to a decline in overall calorie consumption. A fourth line of explanation stresses potential problems in NSS data on calorie intake and even consumption expenditure. Palmer-Jones and Sen (2001) assert that many of India's poverty puzzles arise from under-reporting of expenditures at both the upper and lower tails of the expenditure distribution. In a similar vein, Smith (2013) argues that under-reporting of calorie intake arising due to the increasing prevalence of eating out might explain the calorie consumption puzzle. Without ruling out the importance of this factor, we control for it in our empirical analysis using household level data on the number of meals eaten outside the home.

While all these explanations are plausible and there is evidence in favor of some of them, our investigation of the calorie puzzle proceeds from the observation that there has been a rapid increase in the non-food budget of rural Indian households even as food expenditures have stagnated in real terms (see Figure 2). This has been considered briefly by Deaton and Dreze (2009), but emphasized more substantially by Sen (2005) and Mehta and Venkatraman (2000). However, direct evidence has been lacking thus far. This explanation, which we call the "food budget squeeze hypothesis", advances the possibility that the cost of meeting the nonfood essentials has increased so fast that it has squeezed the food budget, leaving insufficient purchasing power for food. Insufficient incomes to spend on food, in turn, has resulted in calorie intake declines. It is important to note that diet diversification, which has been proposed as a factor in the puzzle can lead to a *decline* in overall calorie intake only in combination with stagnant real food expenditures. If total real expenditure on food grows strongly, dietary diversification can exist along with increases in overall calorie consumption.

In this paper, we test the food budget squeeze hypothesis using household level data from rural India. In the next sub-section, we begin by discussing details of the data used for this analysis. Then we proceed to investigate patterns of expenditure on non-food essential items – real expenditure and as a share of total expenditure – to motivate our empirical investigation of a food budget squeeze.

3 Data and Descriptive Statistics

The empirical analysis in this paper uses household level data from four recent "thick" rounds of the quinquennial Consumption Expenditure Survey (CES) conducted by the National Sample Survey Organization (NSSO): 1987–88 (43rd Round), 1993–94 (50th Round), 2004–05 (61st Round) and 2009–10 (66th Round). The "thick" rounds of the CES are large scale, nationally representative surveys of households, conducted approximately every 5 years, which collect detailed data about the level and pattern of consumption expenditure.

Each "thick round" of the Consumption Expenditure Survey (CES) of the NSSO collects consumption information - value and quantity - on more than 150 food items and an equally large number of nonfood items. Using this information we compute total calorie intake, total real monthly expenditure, and relative price of cereals, noncereals and food. Using information on quantity of consumption and calorie conversion factors (i.e., how many calorie is a unit of a food item equivalent to) provided in various years of the NSSO report "Nutritional Intake in India" (NSSO, 2012), we calculate the calorie intake of each household by summing up the calorie intake from each food item. Dividing this number by the household size gives us the calorie intake per capita. The CES also provides information on value of consumption of all food and nonfood items. By summing them up, we get total monthly expenditure. Dividing that by the household size gives us the total nominal monthly expenditure per capita. To compute real expenditures, we divide nominal expenditure by the state-level consumer price index for agricultural labourers (CPIAL).

To track the movement of relative prices, we construct a Laspeyres price index for cereals, noncereals and food at the state-region level by aggregating household level price data extracted from value and quantity of consumption of over 150 food items.[9] Relative price of food is calculated by dividing the food price index by the CPIAL; relative price of cereals is obtained by dividing the cereal price index with the price index for noncereals.

In our empirical analysis, we control for geographical variation with "state-regions" that are geographical units falling between states (which are bigger) and districts (which are smaller). State-regions are the lowest levels of aggregation at which the representative nature of the CES data is retained. Using detailed information on the creation of new states and districts, and reorganization of districts within states over time, we have constructed 74 unique state-regions that can be consistently compared for all the thick rounds of the CES.

While the "thick rounds" of the CES are the main source of our data, we have also had to access other data sources for two variables that are important for our analysis but not covered by

[9] We follow the method used in Deaton (2008).

Table 1: *Summary Statistics for Key Variables*[a]

	Mean / Standard Deviation			
	1987–88	**1993–94**	**2004–05**	**2009–10**
Calorie Intake (kcal per capita per day)	2291.478	2219.362	2086.684	1970.767
	(672.912)	(622.146)	(542.139)	(513.744)
Total Expenditure (1983 rupees per capita)	24.384	24.347	28.213	31.173
	(23.848)	(20.474)	(17.060)	(21.738)
Fuel Expenditure (1983 rupees per capita)	1.484	1.391	2.577	2.566
	(1.224)	(5.029)	(1.879)	(1.794)
Household size (adjusted for age and sex)	4.234	4.067	4.036	3.870
	(2.076)	(1.937)	(1.953)	(1.836)
Age of household head (years)	43.652	43.780	45.156	45.857
	(13.707)	(13.587)	(13.380)	(13.060)
Meals Eaten Outside Home	7.135	72.723	368.587	353.575
	(23.578)	(17.473)	(186.605)	(175.459)
Diet Diversification Index	34.219	31.736	26.933	24.962
	(12.922)	(11.192)	(8.149)	(7.439)
Access to Safe Water	0.516	0.675	0.821	0.854
	(0.219)	(0.196)	(0.182)	(0.172)
Cooking Source Dummy (Mkt=1, NonMkt=0)	0.048	0.094	0.140	0.162
	(0.214)	(0.291)	(0.347)	(0.368)
Price Ratio (Food/All)	18.398	17.498	17.794	19.158
	(2.244)	(3.025)	(2.293)	(2.622)
Price Ratio (Cereals/Noncereals)	37.753	43.839	40.048	11.448
	(17.876)	(19.375)	(16.834)	(11.055)
Observations	60307	51739	59689	45976

[a] Data are from rounds 43 (1987–88), 50 (1993–94), 61 (2004–05) and 66 (2009–10) of the consumption expenditure survey of the NSSO. Access to safe water is measured at the state-region level as follows: the proportion of households with access to safe potable water. All other variables are measured at the household level.

the CES. The first is the consumer price index for agricultural labourers (CPIAL). We take data for the CPIAL at the state-level from the Economic and Political Weekly Research Foundation (EPWRF) India Time Series data set. The second is information on the percentage of household with access to safe drinking water at the state-region level, i.e., households which use water from taps, hand pumps or tube wells as their source of drinking water. Since the CES does not collect information on source of drinking water, we extract this information from relevant NSS surveys that are closest to the "thick round" years.

After excluding all urban households we have a sample size of 212,913 households for our pooled data set covering more than a 2 decade period from 1987–88 to 2009–10.

Table 1 presents summary statistics for the main variables of interest. Average calorie intake in rural India declined from 2291 Kcal per capita per day in 1987–88 to 1971 Kcal per capita per day in 2009–10, a 14 percent decline over a 2 decade period. Over the same period, real expenditure increased from 24.4 rupees (in 1987 rupees) per capita per month to 31.2 rupees per capita per month, a 28 percent increase. This divergent movement in real expenditure and calorie intake highlights the calorie consumption puzzle.

The key explanatory variable of interest, real expenditure on fuel, increased much more rapidly that total expenditure over this period. Inflation-adjusted expenditure on fuel increased from 1.48 rupees in 1987–88 to 2.57 rupees in 2009–10, a large 74 percent increase (with most of the increase happening before 2004–05). Thus, expenditure on fuel (and other items of nonfood essential expenditure like education, conveyance, rent, etc., as depicted in Figure 2) increased at a much faster rate than overall expenditure. This squeezed the food budget and led to reduced calorie intake, as we demonstrate with our instrumental variable regression methodology below.

The other important factors that have been discussed in the literature as possible determinants of calorie intake display expected movements over the time period of this study. Access to safe drinking water increased secularly, from 52% of households in 1987–88 to 85% in 2009–10, indicating a steadily improving epidemiological environment. The total number of meals reported to have been eaten outside home by all members of the household during the reference month increased rapidly from 7 in 1987–88 to 354 in 2009–10. Diversification of diets increased, with the index falling from 34.22 in 1987–88 to 24.96 in 2009–10.[10] The price of food relative to the CPIAL increased mildly over this period. The price of cereals relative to the price of non-cereals remained relatively unchanged till 2004–05, after which it fell sharply, probably due to a rapid rise in the price of vegetables, fruits, milk, and meat products.

4 Trends in the Food and Non Food Budget

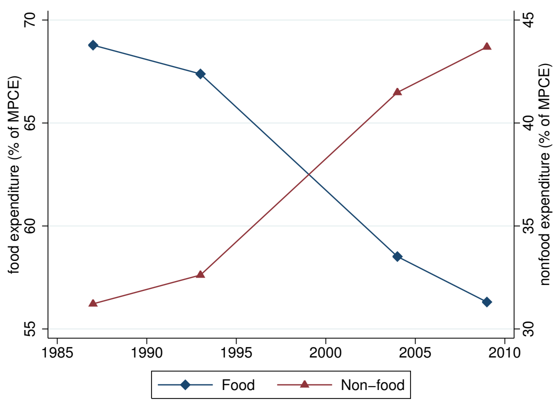
We motivate our subsequent analysis by presenting the recent trends in food and non-food expenditures in rural India. Figure 1 plots the time series of average shares of total monthly per capita expenditures, between 1987–88 and 2009–10, devoted to various broad categories of consumption. The left panel plots the average shares of total monthly per capita expenditure devoted to the mutually exclusive and exhaustive categories of food and nonfood. Over this two decade period, the average share of expenditure going to food items has declined by over 12 percentage points, falling from about 68% to 56%, and the share of nonfood has increased accordingly by about 12 percentage points. The right panel of Figure 1 plots the average share of total expenditure that is devoted to the main nonfood essential items: fuel, education, health care, and conveyance. The share of total expenditure claimed by all these four items have increased substantially over this period. But among these four nonfood "essential" categories, the largest increase has been registered by fuel, with it's share in total expenditure increasing from 6.6% in 1987–88 to 9.6% in 2004–05 before falling slightly in 2009–10.

Figure 1 presents a picture that one expects to see: as incomes rise, the share of food items in total expenditure falls. Further, we also expect that declining share of food expenditures goes hand in hand with an *increase* in real food expenditure. This is because incomes rise fast enough to accommodate both increases on food and nonfood items in real terms.[11] Figure 2 shows that India deviates from this expected pattern. The left panel shows that between 1987–88 and 2009–10,

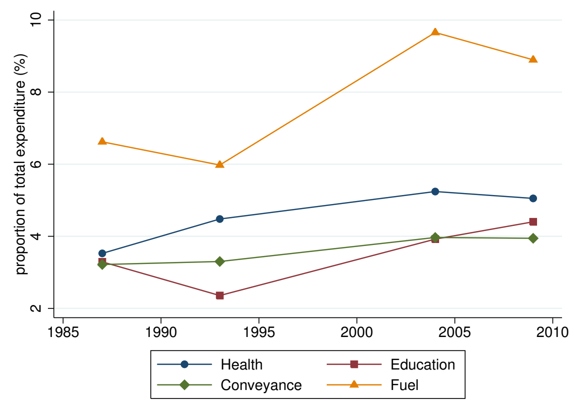
[10] We follow Gaiha et al. (2013) in measuring diet diversification with a Herfindahl-type index, which lies between 0 and 100. A lower value of the index indicates a more diversified diet.

[11] Other than Sub-Saharan Africa, where calorie intake has been stagnant, and transition economies, where calorie intake has declined, most other countries and regions in the world have experienced an increased calorie intake (i.e., increased food consumption). For details, see `http://www.who.int/nutrition/topics/3_foodconsumption/en/` (accessed March 20, 2014).

average non-food expenditures in rural India have close to doubled in real terms, while average food expenditures have virtually *stagnated*. The right panel of Figure 2 plots the time series of average real expenditure on fuel, education, health care, and conveyance. In stark contrast to the real expenditure on food, each of these items have recorded significant increases in real terms. For instance, average real expenditure on fuel has increased by about 86 percent, and average real expenditure on education has registered close to a 95 percent increase; over the same period average real expenditure on food has increased by less than 1 percent. Thus, preliminary evidence in terms of average trends suggest that all the income increases have been absorbed by expenditure on non-food items, so that food expenditures have not increased in real terms.



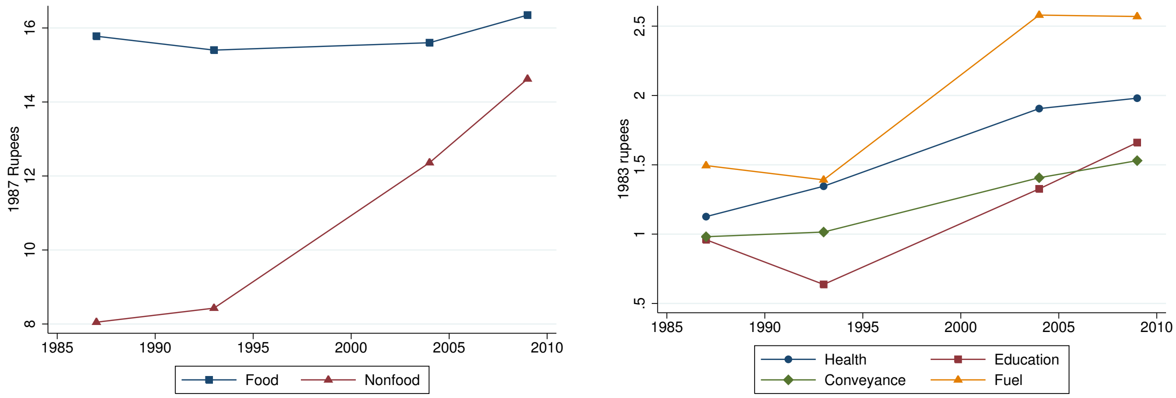
(a) Share of Food and Nonfood in Total



(b) Share of Essential Items in Total

Figure 1: *Average Share of Expenditure on Food and Nonfood in Total Monthly Expenditure, and Average Share of Essentials Items in Total Expenditure. Source: authors' calculation from various NSS rounds.*

While all important components of nonfood essential items – like education, health care, and conveyance – have increased over the period of this study, we choose to focus our attention on fuel expenditure for two reasons. First, among the important components of nonfood essential items, the level of expenditure on fuel is highest and it has also registered a very high growth (see Figures 1 and 2). Second, household level CES data allows us to construct an instrumental variable for real expenditure on fuel – but not for the other components of nonfood expenditure – that is indispensable for our empirical strategy. We discuss the instrument in detail in section 5.1 below.



(a) Real Expenditure on Food & Nonfood Items

(b) Real Expenditure on Nonfood Essentials

Figure 2: *Real monthly per capita expenditure on food and non-food items (1987 rupees). Real expenditures have been calculated by deflating nominal expenditures with the State-level CPIAL. Source: authors' calculations based on various NSS rounds, using CPIAL data from the Economic and Political Weekly Research Foundation India Time Series Data Set.*

5 Empirical Strategy

The key causal relationship we wish to investigate is the effect of real expenditures on fuel on calorie intake. If a food budget squeeze exists, then we should observe a negative relationship between real expenditures on fuel and calorie intake: when real expenditure on fuel increases, that causes a fall in calorie intake.

A bivariate regression of calorie intake on real fuel expenditure would not give us consistent estimates of the food budget squeeze effect because of two reasons. First, given preferences and income, and faced with a set of prices, households jointly determine expenditure on fuel and food, the latter determining calorie intake. Thus, the key explanatory variable, real expenditure on fuel, is endogenous. Second, there are many other factors which have independent effects on calorie intake; hence, leaving them out would lead to omitted variable bias.

To address the second concern, we draw on a long and distinguished literature that has investigated the determinants of the demand for food and calories (Behrman and Deolalikar, 1987; Subramanian and Deaton, 1996). Following this literature, we arrive at the list of covariates that might have independent effects on calorie intake. Hence, we include these variables as explicit controls in our empirical model.

To address the first issue, i.e., endogeneity of real expenditure on fuel, we construct an instrumental variable to capture the exogenous sources of variation in real fuel expenditure. The instrumental variable is a dichotomous variable, which takes a value of 0 for households that report non-commercial sources as their primary source of cooking energy, and 1 for households which use commercial sources as their primary source of cooking energy.

5.1 Energy Source for Cooking

The consumption-expenditure survey conducted by the NSSO collects information about the primary source of energy used by a household for cooking. These are broken up into 8 categories: (1) coke & coal, (2) firewood & chips, (3) LPG, (4) gobar gas, (5) dung cake, (6) charcoal, (7) kerosene, (8) electricity and others. Table 2 provides a break-up of average consumption among these sources of cooking energy. Even though non-commercial sources of cooking energy (firewood & chips, dung cake, and gobar gas) continue to provide the overwhelming portion of cooking energy, their weight has declined over time. In 1987–88, about 95% of cooking energy, on average, came from non-commercial sources; in 2004–05, they accounted for about 83%. The gap has been filled by commercial sources of cooking energy like LPG, kerosene and electricity (with the main increase accounted for by LPG).

Figure 3 shows the importance of commercial sources of energy in rural India, at the aggregate level and by real expenditure deciles. The left panel in Figure 3 shows the time evolution of the proportion of households who report commercial sources as their primary source of cooking energy. The proportion of households using commercial sources of energy has more than tripled, from around 5% in 1987–88 to over 16% in 2009–10. The right panel of Figure 3 shows the use of commercial sources of cooking energy by real expenditure deciles. The use of commercial sources of cooking energy rises steadily across the expenditure deciles, with sharp jumps at the top 3 deciles.

For the energy source dummy to be a good instrumental variable, it must satisfy two properties. First, it must be "relevant", i.e., it must be (strongly) correlated with the endogenous variable. Second, it must be "exogenous", i.e., it must be uncorrelated with the error term in the main causal model, so that the instrument's effect on the dependent variable works only through the

Table 2: *Primary Source of Cooking Energy (percentage of households reporting item as their primary source)*[a]

	1987–88	**1993–94**	**2004–05**	**2009–10**
Source				
Coke & Coal	2.06	1.37	1.12	0.85
Firewood & Chips	81.05	78.77	71.28	77.11
LPG	0.85	1.91	8.16	12.28
Gobar Gas	0.28	0.34	0.33	0.17
Dung Cake	14.13	11.62	8.63	6.21
Charcoal	0.02	0.04	2.56	0.03
Kerosene	1.54	2.05	1.19	0.80
Electricity & other sources	0.07	3.87	3.19	2.56
Expenditure (1987 Rupees)				
Difference (Comm-NonComm)	1.183***	0.868***	2.090***	1.444***
	(37.08)	(29.13)	(75.85)	(61.12)

[a] Data are from rounds 43 (1987), 50 (1993–94), 61 (2004–05) and 66 (2009–10) of the consumption expenditure survey of the NSSO. Sampling weights have been used for computing averages. Source: authors' calculation based on various rounds of NSS. For computing the difference in real expenditure between commercial and non-commercial sources of cooking energy we use the following categorization; commercial: coke and coal, LPG, kerosene, charcoal, and electricity and other sources; non-commercial: firewood and chips, gobar gas, and dung cake. We report t-statistics in parentheses below the estimates of the difference.

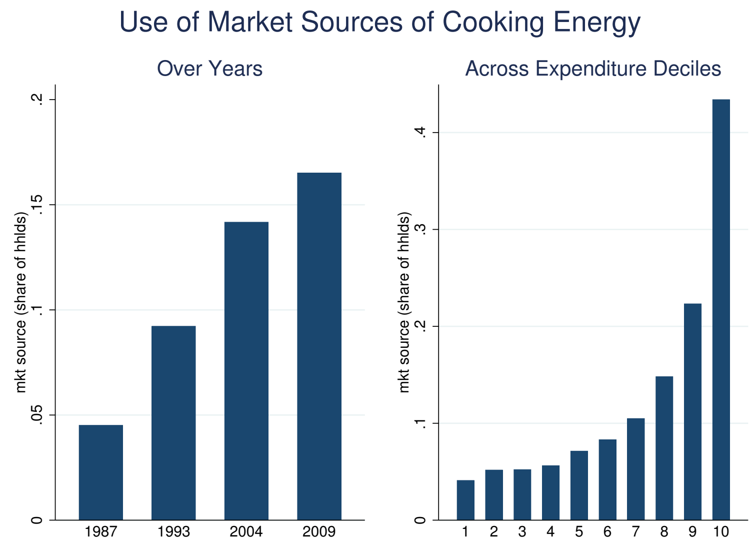


Figure 3: *Proportion of households using predominantly market sources of cooking energy across time and over real expenditure deciles. Market sources include coke & coal, LPG, charcoal, kerosene, electricity, and other sources; non-market sources include firewood & chips, gobar gas, and dung cake. Source: author's calculation based on various rounds of NSS.*

endogenous variable (exclusion restriction).

To see if the relevance condition is satisfied, we investigate the impact of the use of commercial sources of cooking energy on real monthly expenditures. Figure 4 and the bottom panel in Table 2 shows that households using commercial sources of energy spent significantly more on fuel than households using non-commercial fuels as the primary source of cooking energy. The difference was statistically significant in all years in our sample, increasing from 1.18 in 1987–88 to 1.44 in 2009–10. While these figures in terms of raw averages suggest a strong positive relationship between the use of commercial sources of cooking energy and real expenditure on fuel, we present more convincing evidence from our first stage regression in Table 3.

While the exclusion restriction cannot be tested (because the error term is not observed), we draw upon a recent literature on choice of fuel use in developing countries to make our case. Our strategy takes advantage of the fact that controlling for household characteristics such as income (or expenditures), age, and composition, the shift from non-commercial to commercial fuels is driven by supply conditions (accessibility or inaccessibility of fuel sources) which are outside the control of households (Rao and Reddy, 2007; Joon et al., 2009). The shadow price of fuelwood (opportunity cost of time spent in collection) increases with forest degradation and urbanization, as well as improvements in agricultural productivity or availability of non-farm employment that increase opportunity cost of women's time (Heltberg et al., 2000). Cooke et al. (2008) note that household decisions to adopt a certain fuel typically depend on exogenous variables such as wages, market prices, land, natural resources, and demographic characteristics. Migration away from the farm can make households labor-constrained, further increasing the opportunity cost of time spent in fuel collection. Households respond to increasing scarcity by using less of the fuel. Gundimeda and Köhlin (2008) report that geographical area and forest cover are highly significant factors in predicting fuel-type use among rural Indian households, as are changes in forest management practices undertaken by the State (such as Joint Forest Management). On the other hand, the availability of commercial fuels such as kerosene and LPG, either via the public distribution system or the open market, is another important determinant of the switch from non-commercial to commercial fuels. Vishwanathan and Kumar (2005) argue that states such as Himachal Pradesh and Andhra Pradesh have enacted policies that subsidize "clean" fuels such as LPG to reduce forest degradation. Higher use of commercial fuels is thus partly a result of better availability and partly an income effect (Pachauri and Jiang, 2008). It is as the conduit for the impact of these structural changes occurring over time that "primary source of cooking energy" is largely exogenous to household decision-making conditional on income. That is why we think that the energy source dummy satisfies the exclusion restriction and allows us to use it as a valid instrument for real expenditure on fuel.

One potential confound with the instrument is that fuelwood use may affect calorie intake through calorie needs. For example, the literature on women's work and fuelwood use points out that gathering or collection of fuelwood is itself an energy consuming activity (Batliwala, 1982). To the extent that fuelwood dependent households are able to consume more calories due to higher needs, this creates a problem with the instrument. Another possibility is that dependence on fuelwood can negatively affect nutritional outcomes due to the fact that time spent in fuelwood collection is time spent away from agricultural production and cooking. Thus Kumar and Hotchkiss (1988) find for rural Nepal, that degree of deforestation is a determinant of child nutrition, possibly working through reduced agricultural production (increasing time of collection competes with labor input in agriculture), fuel consumption, and time spent for food preparation. Either way, the inclusion of such households could create a potential problem with our instrument.

To address this problem, we perform two types of robustness checks. First, we exclude all households that report using fuelwood as the primary cooking energy course, from our regression analysis and see if the basic result still holds. Second, we take advantage of the fact that in the last two CES rounds (61st and 66th), information was collected on the source of fuelwood, viz. if it was purchased, home-grown, or acquired through "free collection." The last option is the most energy-intensive option since it involves walking over large areas to gather fuelwood. We exclude the households that report "free collection" from the analysis and obtain similar results.

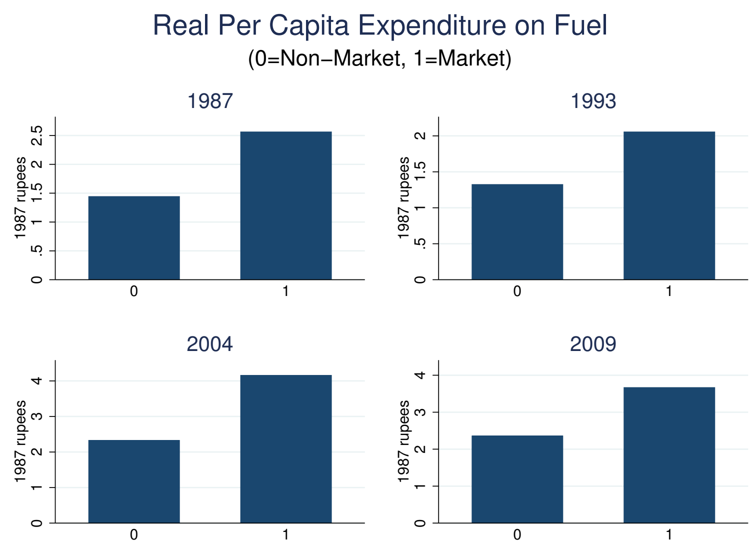


Figure 4: *Real (1987 rupees) expenditure (per capita per month) on fuel from predominantly market and non-market sources of cooking energy. Market sources include coke & coal, LPG, charcoal, kerosene, electricity, and other sources; non-market sources include firewood & chips, gobar gas, and dung cake. Source: author's calculation based on various rounds of NSS.*

5.2 Empirical Model

Our empirical model is a reduced form relationship between calorie intake and fuel expenditure

$$c_{idst} = \alpha + \beta F_{idst} + \theta X_{idst} + \gamma_d + \delta_s + \varepsilon_{idst}, \quad (1)$$

where i indexes households, d indexes real expenditure deciles, s indexes state-regions, and t indexes time periods, γ_d is a real expenditure decile fixed effect, δ_s is a state-region fixed effect, ε_{idst} is an unobserved error term, and α, β and θ are parameters.[12]

The dependent variable (c_{idst}) is the logarithm of calorie intake (Kcal per capita per month), and the key independent variable of interest is the logarithm of real expenditure on fuel purchased from the market (F_{idst}). We instrument real expenditure on fuel with a dichotomous variable for "primary source of cooking energy" (we call it the cooking source dummy). Finally, we add controls by drawing on two strands of relevant literature.

First, the recent literature studying the calorie consumption puzzle in India has suggested the following possible determinants of calorie intake: declining calorie needs as caused by the changing epidemiological environment and occupational diversification away from agriculture (Deaton and Dreze, 2009); diversification of diets that implies substitution of relatively expensive for cheaper sources of calories (Rao, 2000); relative price movements, i.e., prices of food relative to nonfood items, and prices of cereals relative to non-cereals (Deaton and Dreze, 2009; Gaiha et al., 2013); meals eaten outside home that leads to under-reporting of actual calorie intake (Smith, 2013); and reduction in home grown sources of consumption (Mehta and Venkatraman, 2000). We include controls for each of these potentially important variables: an index of diet diversification, the ratio of food prices to a general price index (the state-level CPIAL), the ratio of cereal prices to non-cereal prices (calculated at the household level), number of meals eaten outside home by all members of the household, proportion of households with access to safe water (at the state-region level) as a proxy for the epidemiological environment, 99 occupation (2 digit NCO categories[13]) dummies to capture changes in activity levels engaged in by the workforce, and the proportion of cereal consumption coming from home grown stock.[14]

Second, we draw on an older literature that had investigated the determinants of food and calorie

[12]This reduced form calorie demand equation can be understood as emerging from the first order conditions of household level constrained optimization (Behrman and Deolalikar, 1987).

[13]Before the 66th round, the CES had been using NCO 1968; from the 66th round, it started using NCO 2004. We have used conversion tables provided by the NSSO to create comparable 2 digit codes spanning our period of study.

[14]While we acknowledge that there might be concerns about endogeneity of the diversification index, we think that it is not a serious problem in this case because we have controlled for covariates that would have led to omitted variable bias. The two main such covariates are the relative price of cereals to noncereals, and real expenditure (as a proxy for income).

demand (Behrman and Deolalikar, 1987; Subramanian and Deaton, 1996) to include the following additional controls: household size adjusted for age and sex composition of each household, age (and its square) of household head, schooling of household head, reported caste and religion of the household, and a time trend.

The key feature of our empirical model is the inclusion of dummies for deciles of real monthly household expenditure (γ_d) and state-region (δ_s) fixed effects.[15] This allows us to exploit variation *within* expenditure deciles and state-regions over time to estimate parameters of interest.

For our empirical strategy, variation within real expenditure deciles, captured by the inclusion of real expenditure decile dummies, is important for two reasons. First, it allows us to control for the effect of income - with expenditure understood as a proxy for income - on fuel expenditure and calorie intake. Failure to control for income might lead to an omitted variable bias. Second, by comparing households across four time periods, 1987–88, 1993–94, 2004–05 and 2009–10, within each real expenditure decile, we are able to capture the crucial effect of income growth over time. Within each real expenditure decile, there are households from four different time periods, 1987–88, 1993–94, 2004–05 and 2009–10. Since over this period, per capita real expenditure has grown within each decile, households from later periods would generally have higher real expenditure than households from earlier periods. By comparing these households, which are similar in all other observable respects, we are able to mimic the comparison of the households over time. Thus, the use of the energy source dummy in conjunction with within-expenditure-decile comparison allows us to consistently estimate the effect of the food budget squeeze.

6 Regression Results

6.1 Fuel Expenditure and Calorie Intake Decline

Table 3 presents estimates of the reduced form model (calorie intake regressed on the energy source dummy and all the included exogenous regressors) and the first stage regression (real fuel

[15]Real monthly per capita expenditure deciles refer to the distribution of real monthly per capita expenditure, where the latter is computed for each household in the pooled data set by deflating the household's nominal monthly per capita expenditure by the CPIAL.

expenditure regressed on the energy source dummy and all the included exogenous variables). In the reduced form regression, the coefficient on the cooking energy source dummy is -0.037 and statistically significant, providing evidence of a food budget squeeze; the other variables have expected signs. In the first stage regression, the coefficient on the cooking energy source dummy is 0.209 and statistically significant; other variables have expected signs too.

Table 4 presents two stage least squares (2SLS) estimates of the model parameters, using the cooking energy source dummy as an instrument for real fuel expenditure. The underidentification test result suggests that the instrument is strongly correlated with the endogenous variable. Since this is an exactly identified model, we cannot test the exogeneity of the instrument with an overidentification test. The coefficient on the main variable of interest, real fuel expenditure is around -0.18 (as one would expect from the reduced form model and the first stage regression, i.e., $-0.18 = -0.037/0.209$) and is statistically significant in all model specifications. In Table 4, specification (1) is the basic model; specification (2) adds 99 occupation dummies; specification (3) adds a control for access to safe water; specification (4) adds home grown cereals; and specification (5) adds a time trend. The coefficient on fuel expenditure changes somewhat (from -0.189 to -0.178) but remains strongly statistically significant. In quantitative terms, the coefficient can be interpreted as follows: in rural India, a 1 percent increase in fuel expenditure caused a decline in calorie intake of about 0.18 percent, even after controlling for relevant covariates like diet diversification, relative price movements, changes in the epidemiological environment, changes in the occupational structure of the workforce, income growth and demographic factors.

In terms of the other factors that have been proposed in the recent literature as possible determinants of calorie intake, diversification and relative prices emerge as statistically and economically significant in our estimation results. A more diversified diet (smaller index) is associated with lower calorie intake and higher relative price of food compared to non-food expectedly decreases calorie intake. The coefficient on the index for diet diversification is 0.007 and remains statistically significant in all specifications suggesting that a 1 percent increase in the diversification index reduces calorie intake by 0.7 percent.[16] The relative price of food has a consistently negative effect on

[16]Recall that the diversification index ranges between 0 and 100.

Table 3: *Reduced Form and First Stage Regression Results*[a]

	(1) Reduced Form	(2) First Stage
Cooking Source Dummy (Mkt=1, NonMkt=0)	-0.037***	0.209***
	(0.005)	(0.034)
Diet Diversification Index	0.007***	-0.002*
	(0.000)	(0.001)
Log Price Ratio (Cereals/Noncereals)	-0.006***	0.053***
	(0.002)	(0.007)
Log Price Ratio (Food/All)	-0.417***	0.469***
	(0.034)	(0.136)
Household size (adjusted for age and sex)	-0.014***	-0.118***
	(0.001)	(0.004)
Age of household head (years)	0.008***	0.001
	(0.001)	(0.002)
Occupation Dummies	Y	Y
State-Region Fixed Effects	Y	Y
Expenditure Decile Fixed Effects	Y	Y
Time Trend	Y	Y
Adjusted R-sq	0.57	0.48
Observations	212913	212913

[a] This table reports reduced form and first stage regression results for the 2SLS estimates presented in Table 4. Fuel expenditure is instrumented with a cooking source dummy. All specifications use sampling weights and robust standard errors, clustered by state-region, appear in parentheses below parameter estimates. Additional controls in each specification include the following: number of meals eaten outside home, access to safe drinking water, proportion of cereals coming from home grown stock, age (and square of age) of household head, caste dummies, religion dummies, education dummies (for the household head), 99 occupation dummies and a time trend. To prevent outliers from driving results, we drop observations at the top and bottom 1% of the calorie intake distribution. Significance levels: *** 1 percent; ** 5 percent, * 10 percent.

calorie intake: a 1 percent increase in the relative price of food reduces calorie intake by about 0.33 percent. The coefficient on the price of cereals relative to the price of non-cereals is positive but small (about 0.008), suggesting that cereal is probably a Giffen good in rural India. Since the elasticity of the relative price of cereals to non-cereals is very small (and in the specification with a time trend it is statistically insignificant), its economic effect is not very meaningful for explaining calorie intake changes.

On the other hand, access to safe water, number of meals eaten outside home and a measure of cereals grown at home do not emerge as statistically significant determinants of calorie intake.[17] The effect of household size and age of the household head is in line with existing results. Household size (adjusted for sex and age of the household members) has a negative impact on calorie intake. Probably this hints at the existence of within-household economies of scale in calorie consumption. The age of the household head has a nonlinear effect on calorie intake: the coefficient on age (of household head) is positive and coefficient on the square of age is negative, with both being statistically significant.[18]

One way to intuitively understand these results is to connect the food budget squeeze and diversification. Galloping expenditures on nonfood essentials, in particular fuel, absorbed all the increases in income and squeezed the food budget. How? The mechanism that we have in mind works through the differential cash requirements of fuel source. While non-commercial fuels are available largely without cash transactions, procurement of commercial fuels like LPG and kerosene requires cash. In effect, therefore, the switch from non-commercial to commercial sources of fuel is equivalent to an increase in the price of fuel. To this, one must juxtapose the fact that most of the calorie intake comes from cooked food, making the demand for fuel relatively inelastic. Thus, when there is an increase in the price of fuel – as entailed by the switch from non-commercial to commercial sources – real expenditure on fuel increases and reduces the budgetary allocation for food. A squeezed food budget and changes in the relative price of food led to stagnant real food expenditures (see Figure 2(a)). Dietary diversification, in conjunction with stagnant real food

[17] While we control for the effect of occupational changes by including 99 occupational dummies in our regressions, in this paper we do not explicitly analyse their impact.

[18] The magnitude of the coefficient on age-square is very small; hence, we do not report it in Table 4.

Table 4: *Instrumental Variable Regression Estimates of Food Budget Squeeze: Rural India*[a]

Dep Var: Log Calorie Intake	(1)	(2)	(3)	(4)	(5)
Log Real Fuel Expenditure	-0.189***	-0.183***	-0.181***	-0.182***	-0.178***
	(0.023)	(0.026)	(0.026)	(0.026)	(0.027)
Diet Diversification Index	0.007***	0.007***	0.007***	0.007***	0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log Price Ratio (Cereals/Noncereals)	0.009***	0.009***	0.008***	0.008***	0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Log Price Ratio (Food/All)	-0.327***	-0.334***	-0.331***	-0.330***	-0.334***
	(0.057)	(0.055)	(0.055)	(0.055)	(0.052)
Household size (adjusted for age and sex)	-0.033***	-0.031***	-0.032***	-0.032***	-0.035***
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)
Age of household head (years)	0.008***	0.008***	0.008***	0.008***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Occupation Dummies	N	Y	Y	Y	Y
State-Region Fixed Effects	Y	Y	Y	Y	Y
Expenditure Decile Fixed Effects	Y	Y	Y	Y	Y
Time Trend	N	N	N	N	Y
Adjusted R-sq	0.374	0.352	0.355	0.353	0.365
Underidentification Test (p-value)	0.000	0.000	0.000	0.000	0.000
Observations	217331	212916	212916	212913	212913

[a] This table reports regression results using a pooled data set drawn from rounds 43 (1987–88), 50 (1993–94), 61 (2004–05) and 66 (2009–10) of the consumption expenditure survey of the NSSO. Fuel expenditure is instrumented with a cooking source dummy. All specifications use sampling weights and robust standard errors, clustered by state-region, appear in parentheses below parameter estimates. The model has been estimated with 2SLS. Specification (1) is the basic model; specification (2) adds 99 occupation dummies; specification (3) adds a control for access to safe water; specification (4) adds home grown cereals; and specification (5) adds a time trend. Additional controls in each specification include the following: number of meals eaten outside home, access to safe drinking water, proportion of cereals coming from home grown stock, age (and square of age) of household head, caste dummies, religion dummies, education dummies (for the household head), 99 occupation dummies and a time trend. To prevent outliers from driving results, we drop observations at the top and bottom 1% of the calorie intake distribution. Significance levels: *** 1 percent; ** 5 percent, * 10 percent.

expenditure, led to declines in calorie intake.

Thus, our results suggest that even though inflation-adjusted real expenditures in rural India have increased during this period, they have not increased enough to accommodate both, an increased need for spending on non-food essentials, as well as sustained nutritional intake. Since our results for IV regressions consistently show a negative and statistically significant coefficient on real fuel expenditure, we can conclude that this effect is indeed strong and remains in operation even after we have controlled for real expenditure growth, the relative price of food, diversification of diets and possible changes in calorie needs (captured by occupation dummies and the access to safe water variable).

6.2 Robustness Checks

As mentioned earlier, it can be argued that fuelwood-dependent households have greater calorie needs than household using kerosene or LPG, since a significant amount of energy is expended in collection of fuelwood. If these greater needs translate into greater calorie consumption, then our specification is no longer cleanly identified, since the cooking source dummy affects calorie intake through needs rather than fuel expenditure. To test whether this effect is driving the results presented above, we undertake two robustness checks.

First, we re-estimate the model for a sub-sample by excluding all households that report fuelwood as the primary source of cooking energy. The model is otherwise identical to that reported in the previous section. Excluding fuelwood leaves dung cake as the most important form of non-commercial fuel. Table 2 shows that over the period of analysis, households using dung cake as the primary source of cooking energy decreased from 14.13% in 1987–88 to 6.21% in 2009–10. Over the same period, households using LPG as the primary source of cooking energy increased from 0.85% to 12.28%. Indeed, LPG emerges as the most important commercial fuel source in rural India over this period, increasing at the expense of both dung cake and fuelwood.

Specification (1) in Table 5 reports the results of a 2SLS estimation for the sub-sample that excludes fuelwood using households. The coefficient on fuel expenditure reduces in magnitude (from around -0.18 to -0.07) but remains negative and statistically significant. The drop in the value of the key coefficient might be because we have a cleaner identification of the food budget squeeze effect or because the food budget squeeze is weaker among households that do not use fuelwood (because they face a smaller monetary squeeze from switching to commercial sources of fuel). The other coefficients are similar to those reported for the full sample.

As a second check, we re-estimate our model by excluding households which report "free collection" of fuelwood. The latest two NSS thick rounds (61st and 66th) contain information on whether fuelwood used for cooking was purchased, home-grown or acquired via "free collection." Assuming that purchasing or using home-grown fuelwood does not entail the same energy requirement as free collection (which occurs over a larger area, including forests), by excluding these households we are able to mitigate the possible problem of the cooking source dummy affecting calorie intake through calorie needs without losing the entire sample of households that reports fuelwood use. The results of this estimation are reported in Column (2) of Table 5 and are substantially similar to the results reported in the previous section. The coefficient of the principal explanatory variable of interest, real fuel expenditure, at -0.115 is in the same range as for the full sample, while those for the diversification index, household size, and age of head are nearly identical. The price ratio, however, has a much larger effect over this period (-0.734 as compared to -0.33) indicating that the relative price of food has become a much more salient determinant of calorie intake over the past decade as compared to earlier.[19]

In both our robustness checks, the main result of the paper persists, i.e., we find strong evidence of a food budget squeeze. Since our robustness strategies were meant to remove possible links between fuelwood use and calorie intake that runs through calorie needs, we conclude that such a channel, even if it exists, does not undermine the food budget squeeze mechanism identified by our empirical strategy.

We recognize that we face a trade-off in our empirical strategy. When we use the full sample, we face the possible problem that the food budget squeeze is not cleanly identified. This is because the cooking source dummy might have an impact on calorie intake that runs through calorie needs. While we acknowledge that this possibility exists, we do not think that it seriously undermines

[19]This is not surprising because food prices in India have displayed a secularly upward trend since the early 2000s.

Table 5: *Robustness Checks for IV Regression Results*[a]

	(1)	(2)
Log Real Fuel Expenditure	-0.073***	-0.115***
	(0.018)	(0.021)
Diet Diversification Index	0.007***	0.008***
	(0.000)	(0.001)
Log Price Ratio (Cereals/Noncereals)	0.004	-0.005
	(0.004)	(0.004)
Log Price Ratio (Food/All)	-0.375***	-0.734***
	(0.057)	(0.236)
Household size (adjusted for age and sex)	-0.023***	-0.024***
	(0.003)	(0.005)
Age of household head (years)	0.008***	0.009***
	(0.001)	(0.001)
Occupation Dummies	Y	Y
State-Region Fixed Effects	Y	Y
Expenditure Decile Fixed Effects	Y	Y
Time Trend	Y	Y
Adjusted R-sq	0.474	0.457
Underidentification Test (p-val)	0.000	0.000
Observations	50023	53197

[a] This table reports 2SLS estimates for two sub-samples. As before, fuel expenditure is instrumented with cooking source dummy. All specifications use sampling weights and robust standard errors, clustered by state-region, appear in parentheses below parameter estimates. Specification (1) uses a sub-sample where all households reporting fuelwood as primary source of cooking energy have been dropped. Specification (2) uses a sub-sample, where all households reporting "free collection" of fuelwood as primary source of cooking energy have been dropped. Due to data limitations, specification (2) could be estimated with data from Rounds 61 and 66 only. Additional controls in each specification are as reported in Table 4. To prevent outliers from driving results, we drop observations at the top and bottom 1% of the calorie intake distribution. Significance levels: *** 1 percent; ** 5 percent, * 10 percent.

our result because we have already controlled for income and a host of other relevant factors. On the other hand, when we use a sub-sample that excludes all fuelwood-using households, we are, in principle, able to get a cleaner identification of the food budget squeeze but only after discarding a huge amount of useful information (close to 70 percent of the households, which use fuelwood, are discarded). Thus, while recognizing this potential trade-off, we are confident in our result that the food budget squeeze does exist (because all specifications and robustness checks throw up statistically significant effects) and are happy to concede that the numerical estimate lies somewhere between -0.07 and -0.18.

7 Discussion and Conclusion

A puzzling feature of Indian economic development over the past few decades has been the trend movement of per capita real income (measured by real MPCE or per capita real GDP) and average per capita calorie intake in opposite directions. While per capita real incomes have increased, average per capita calorie intake has declined over time. This is extremely worrisome because the vast majority of the population in rural India fall below the required dietary allowance (RDA), i.e., the minimum calorie intake required for a healthy and active life, specified by the Indian Council of Medical Research. For instance, according to the data used in this study, 76.45 percent of the rural population reported a calorie intake below 2320 Kcal per capita per day (the minimum RDA for males in rural India engaged in sedentary activity) in 2009–10.

Several explanations have been offered for this puzzling phenomenon, including movements in relative prices, impoverishment of a large section of the population in rural India, diversification of diets, decline in calorie needs, under-reporting of actual calorie intake due to increased prevalence of eating outside home and a squeeze of the food budget.

Using household-level data from 4 recent "thick" rounds of the NSS Consumption Expenditure Survey (1987–88, 1993–94, 2004–05 and 2009–10) this paper tests for these alternative explanations of the calorie intake puzzle in rural India. Using a novel instrumental variables estimation strategy, this study presents strong evidence supporting the food budget squeeze hypothesis. Our empirical analysis shows that households which spent 1% more on fuel expenditure in real terms, consumed between 0.07% and 0.18% less calories after controlling for total real expenditures, diet diversification, relative price changes, and potential changes in calorie needs (captured by occupational changes and epidemiological changes). Other covariates that contribute to the calorie intake decline are diversification of diets, and change in the relative price of food. On the other hand, increase in real expenditure (as a proxy for income growth) has mitigated the decline in calorie consumption.

A possible mechanism underlying the calorie consumption puzzle operates through a combination of the food budget squeeze and dietary diversification. In the case of fuel, the underlying mechanism has worked through the switch from non-commercial sources of fuel (like fuelwood and dung cake) to commercial sources of fuel (like LPG and kerosene). Non-commercial fuels can be largely acquired without cash but commercial fuels require cash transactions. Therefore, the switch from non-commercial to commercial fuels is equivalent to an increase in the price of fuels. Moreover, calorie intake comes predominantly from cooked food, which means that the demand for fuel is relatively inelastic. Hence, the increase in price of fuel leads to an increase in fuel expenditure, which, in turn, squeezes the budgetary allocation for food. A squeezed food budget and changes in the relative price of food have led to stagnant real food expenditures (see Figure 2(a)). Dietary diversification, in conjunction with stagnant real food expenditure, has caused the observed declines in calorie intake.

The findings from this study have immediate policy implications. Since relatively rapid income growth over the past three decades in India has not translated into improvements in nutritional status of the vast majority of the population, the State needs to adopt policies to address the problem of under-nutrition. In formulating polices that might address the deterioration in nutritional status, policy makers will need to take account of the operation of a food budget squeeze.

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